DESCRIPTION OF THE LARVA OF *PHLOEODES DIABOLICUS* LeCONTE (COLEOPTERA: ZOPHERIDAE)

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Abstract

The larva of *Phloeodes diabolicus* (Coleoptera: Zopheridae) is characterized and the relationship of the Zopheridae to other heteromerous beetles is discussed.

The family Zopheridae was first proposed on the basis of larval characteristics of *Phellopsis obcordata* Kirby (Böving and Craighead, 1931). More recently Crowson (1955) and Watt (1967; 1974) have supported the separation of the Zopheridae from the Tenebrionidae because of differences among the adults. The larva of *Phloeodes* is strongly modified for wood boring, most noticeably in the enlarged thoracic region and reduced legs, but in structural details is very similar to that of *Phellopsis*. It may be surmised that other zopherid larvae, at least of the Nosoderminae, will show a high similarity in most of the features described below. Zopherid larval substrates are rotting wood or associated fungus, as far as known. Most are probably nonspecific decomposers. For example, *Phloeodes* is recorded from *Populus*, *Quercus*, and *Morus* (introduced), and probably utilizes many other trees as well.

Phloeodes diabolicus LeConte

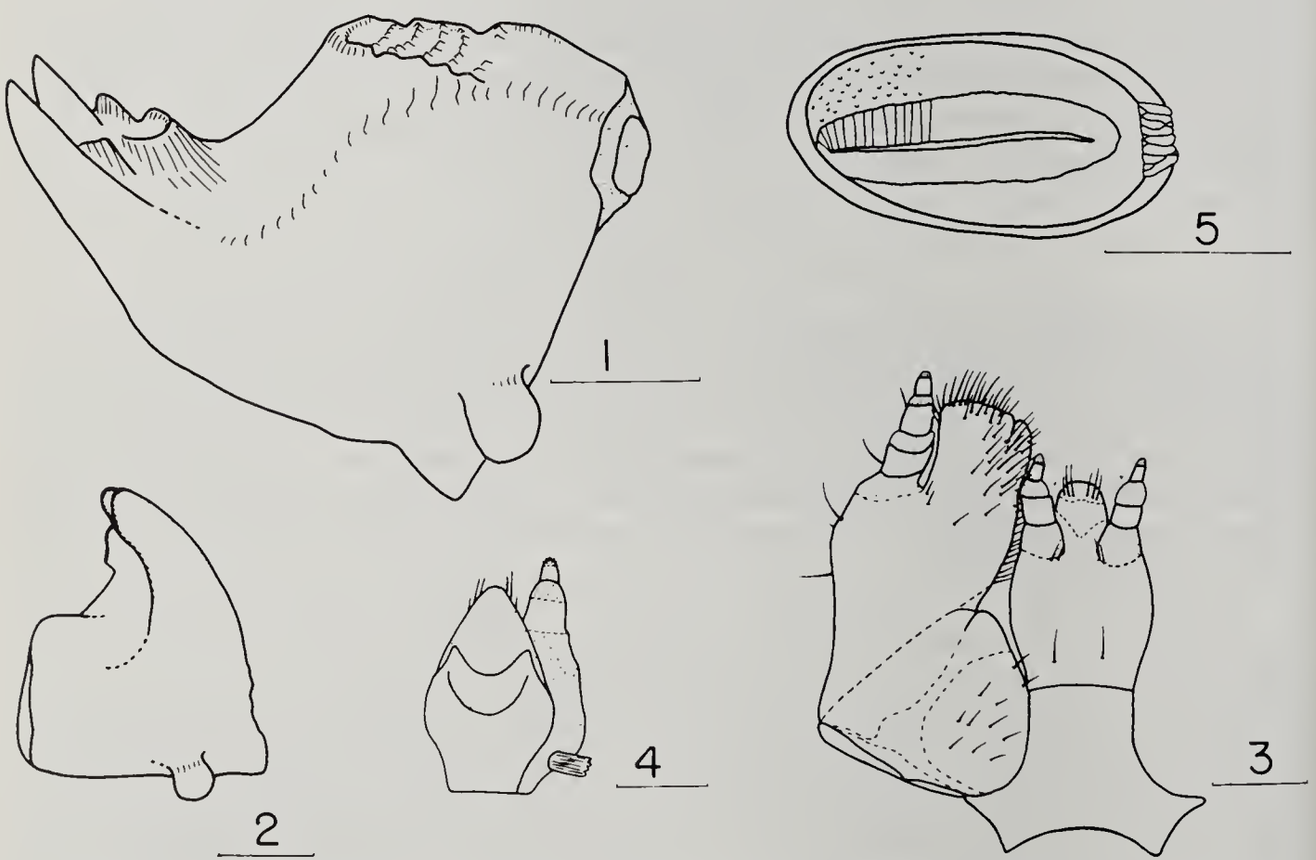
Intermediate and late instar larva. Body elongate, moniliform when expanded (fig. 6), stout, linear when contracted; desclerotized, white or pale creamy, becoming light tan in preserved specimens; cranium, pronotum, and dorsal sclerites on mesothorax, metathorax, and legs lightly sclerotized, very pale tan, becoming tan in preserved specimens; claws, urogomphi, mandibles, and mandibular, clypeal, and maxillary articulations sclerotized, black.

Cranium (fig. 7) subquadrate, slightly flattened dorsoventrally, prognathous, ocelli absent; cranium glabrous, polished, except for scattered, short setae on dorsal and lateral surfaces and patches of short setae near dorsal mandibular articulations; clypeus desclerotized, whitish, glabrous; labrum protruding anterad, lightly sclerotized, sparsely setose. Antennae articulated with strong prominences on anterolateral margin of cranium; prominences darkly pigmented in mature specimens. Mandibles massive, strongly prognathous; incisor lobe apically bidentate, apical teeth closely subtended by smaller tooth on middle of inner surface and by 2 smaller teeth on dorsal, interior margin (figs. 1, 2); mola massive, with sharp, strong ridge along anterior margin, followed by 3 or 4 weaker, irregular, asperate ridges; posterior half of mola smooth, subplanar; submolar structures absent. Maxilla (fig. 3) thick, fleshy; cardo bipartite, with lightly sclerotized, subtriangular lobe ventrally, more strongly sclerotized, strut-like lobe basally, remainder of ventral surface membranous; stipes

lightly sclerotized, continuous with apically incised mala, which is armed with simple setae, densest at apex of inner lobe. Submentum and mentum strongly sclerotized in mature individuals, divided by distinct articulation; prementum membranous except for small sclerites at bases of palpi, continuous with mentum, without distinct articulation; ligula with basal sclerotization, apex densely setose; hypopharyngeal sclerome strongly sclerotized, bilobed, directed anterad (fig. 4).

Prothorax enlarged, flattened, partly enveloping head in contracted specimens (fig. 7); pronotum glabrous, except for extremely sparse, short, erect setae; prosternum transverse, without distinct sutures (fig 8); preepipleurum not apparent, epipleurum as small vertical sclerite articulated with coxa; sternellum reduced, desclerotized. Mesothorax and metathorax similar, transverse, narrow; notal shields with transverse line of flattened, sessile, backwardly directed denticles; sterna fleshy, membranous, transversely connecting coxae. Mesothoracic spiracle enlarged, elliptical, annular-biforous, set in membrane between mesopleuron and propleuron; peritreme slightly elevated, sclerotized; atrium flexible, densely set with fine granules (fig. 5). Metathoracic spiracle small, elliptical, annular-biforous, set in membrane between metapleuron and mesopleuron.

Abdominal segments moniliform, first segment moderately transverse, segments 2 through 8 subquadrate, broadest in posterior third (fig. 6); first 2 segments with transverse line of denticles; nota and sterna of first 8 segments glabrous except for very sparse, short, erect setae; abdominal spira-

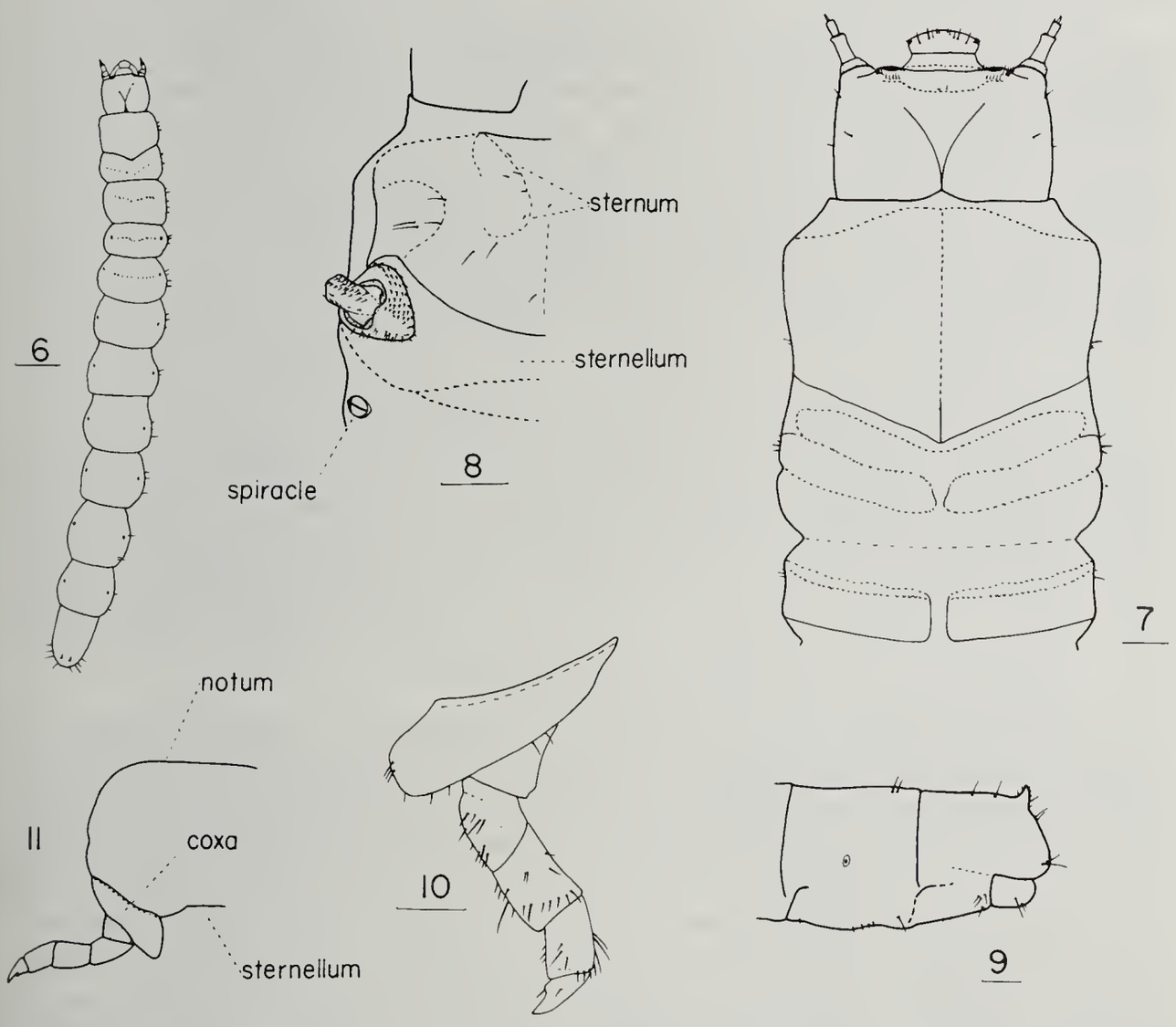


Figs. 1-5. *Phloeodes diabolicus*, mouthparts and mesothoracic spiracles. Lengths of scale lines in parentheses. Fig. 1. Right mandible of late instar larva, oblique ventral aspect (scale line = 1.0 mm). Fig. 2. Left mandible of intermediate instar, ventral aspect (0.5 mm). Fig. 3 Right maxilla and labium of intermediate instar, ventral aspect (0.5 mm). Fig. 4. Ligula and hypopharynx of intermediate instar, dorsal aspect (0.5 mm). Fig. 5. Mesothoracic spiracle, dorsal surface on right (0. 5 mm).

cles similar to mesothoracic spiracle, except for smaller size. Ninth abdominal segment with notum narrow, elongate, subconical, with short, anteriorly curved urogomphi; ninth sternite transverse; tenth sternite transverse, slightly protuberant, without pygopods or exceptional setation (fig. 9).

Legs short, slender, weakly sclerotized; coxae large, transverse, conical, protruding mesally, where trochanter is articulated (figs. 10-11); trochanter, femur and tibia subequal in length, cylindrical; claw colorless, thickened basally, with 2 short setae.

Mature, expanded larvae measure up to 51 mm long in the material examined, but contracted specimens are much shorter. The distribution of head capsule widths in the 13 available specimens suggests that 4 intermediate to late instars are probably represented. Early instars are unknown. The smallest specimens examined differ from more mature individuals in being paler, with less extensive sclerotization of the legs, urogomphi, and mouthpart articulations on the cranium. Dentition of the mandibles is more complex in later instars, with the subapical teeth becoming



Figs. 6-11. *Phloeodes diabolicus*, various larval structures. Lengths of scale lines in parentheses. Fig. 6. Dorsal aspect of late instar larva (2.0 mm). Fig. 7. Cranium and thoracic segments, intermediate instar, mandibles excised (1.0 mm). Fig. 8. Prosternal region, late instar (1.0 mm). Fig. 9. Terminal abdominal segments, intermediate instar, lateral aspect (1.0 mm). Fig. 10. Right prothoracic leg, intermediate instar, posterior aspect (0.5 mm). Fig. 11. Diagram of cross section through prothorax.

relatively larger and the anterior molar surface with parallel rows of asperities (fig. 1). Setation on the cranium, maxillae, and labium is sparser in the smallest specimens, and the spination on the legs is much reduced.

Material examined. California, Riverside County, Riverside, V-13-1971, L. D. Anderson, ex cottonwood (*Populus*) logs (4 larvae; various instars; associated with reared adults); Neuvo, IX-17-1971, ex mulberry (*Morus*) roots (7 larvae, various instars); Monterey County, 6 mi N. Greenfield, V-10-1975, J. Doyen, Ex *Quercus* log (2 larvae, J. Doyen Lot 75E5).

Discussion

The Zopheridae were originally separated from the Tenebrionidae chiefly on the basis of larval maxillary structure (Böving and Craighead 1931). Subsequent workers, while concurring with the separation of the Zopheridae, have not chracterized the larvae or clarified their differences from the Tenebrionidae. Important divergences exist in several features, especially leg and thoracic structure, spiracles, and terminal abdominal segments.

In the Tenebrionidae and Tentyriidae (sensu Doyen 1972) the mala is usually undivided, whereas in the Zopheridae it is apically bifid. This was the differentiating character emphasized by Böving and Craighead. In some Tenebrionidae (some *Eleodes*) the mala is strongly indented apically (Doyen, unpublished) and superficially similar to the condition in the Zopheridae. However, other features of the mouthparts appear to separate the 2 taxa. In most larval Tenebrionidae the mandibles are of relatively simple structure, with 2 or 3 incisor teeth and with the mola of planar configuration. In known zopherid larvae the mandibles have the incisor lobe tridentate (*Phellopsis*) or multidentate (*Phloeodes*), and the mola transversely ridged.[1] In known Tentyriidae the larval mandibles bear a tuft of macrosetae inserted in a dorsolateral or ventrolateral membranous patch, differentiating them from Zopheridae as well as Tenebrionidae. In the Tenebrionidae and Tentyriidae, the labrum is transverse and widest at the base. In the Zopheridae, the labrum is basally narrowed, with the length and breadth subequal (fig. 7). In addition, the ventral mouthparts of the Zopheridae are fleshy, desclerotized, and inflated. In the Tenebrionidae and Tentyriidae the maxillae and labrum are relatively more strongly sclerotized and not inflated or protuberant.

In Tenebrionidae, and especially in Tentyriidae, the larval legs are strongly developed for digging, especially on the prothorax. In the Tentyriidae the contiguous procoxae are enclosed posteriorly by the enlarged sternellum, and the forelegs are directed anteroventrally (Brown 1973; Doyen 1974). In contrast, in *Phloeodes* and *Phellopsis* the legs are relatively small and weak and are attached laterally, with a large intervening sternal region (figs. 8, 11). In both genera the coxae are transversely conical, with the sternellum undifferentiated. Rows of asperities on the thoracic nota are present in various wood-boring beetle larvae including Oedemeridae, Monommidae, and some Colydiidae and are a useful diagnostic feature only in conjunction with other characters.

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[1]As indicated by Watt (1974) some Tenebrionidae (Diaperinae, Phrenapatinae) have the larval mola ridged. It may be significant that these taxa, as in the Zopheridae, inhabit ligneous substrates.

In most Tenebrionidae and Tentyriidae the tenth abdominal segment bears protrusible pygopodial lobes frequently armed with spines or bristles, especially in soil-dwelling forms. In *Phloeodes* and *Phellopsis* the tenth segment comprises a rounded, ventral lobe, without indication of pygopodia (fig. 9).

Affinities of the Zopheridae are not clear. Adult characters suggest relationships with the Tenebrionidae or Tentyriidae (5-5-4 tarsal formula; procoxal cavities closed externally, with a few exceptions; male and female genitalia of tenebrionoid configuration). The absence of defensive glands and external membranes between terminal abdominal sternites, the inverted orientation of the aedeagus, and the relatively large mentum are characters shared with the Tentyriidae (see Doyen 1972). However, as described above, larval characteristics strongly differentiate Zopheridae from both Tenebrionidae and Tentyriidae. In addition, the Tentyriidae are strongly arid adapted organisms, with notable radiations in most of the world's deserts. The Zopheridae almost always occupy woodland or forest habitats and are especially well represented in seasonally wet temperate and montane tropical forests. All known larva of Tentyriidae are soil dwellers, while known zopherids tunnel in rotting wood.

The complex larval mandibular dentition and annular biforous spiracles of the Zopheridae are similar to those of *Othnius*, some Colydiidae, Cephaloidae, and *Synchroa*. *Synchroa* is also similar in maxillary and leg base structure. It is similar to *Phellopsis* (but not *Phloeodes*) in configuration of the frontoclypeal suture and general body configuration. *Synchroa* differs from the Zopheridae in possessing asperities on the 9th sternite, but lacking them on the thoracic tergites. Many of these similarities and differences were informally recognized by Böving and Craighead (1931:190-191) and Peterson (1957:180-183).

No larvae of the Zopherinae have been described. Adults of *Usechus* and *Usechimorpha* (Tentyriidae, Usechini) are morphologically similar to the Nosoderminae. All are associated almost exclusively with decaying wood, where the immatures presumably occur. Description of these larvae will be necessary to complete a characterization of the Zopheridae and to precisely delimit the family.

Acknowledgments

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